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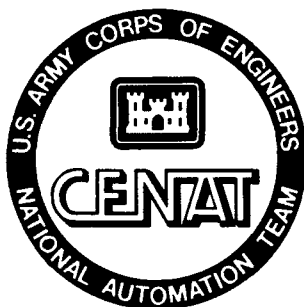
October 1991

T³B: Test of MicroStation Computer-Based Instruction

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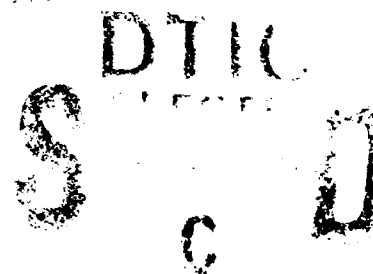
TECHNOLOGY
TRANSFER
TEST BED
PROGRAM



91-18876

Adaptive On-Line Help for Embedded Instructional Systems

by
Doris Smith Shaw
L. Michael Golish
Julie L. Webster
Der-Shung Yang



The U.S. Army Corps of Engineers (USACE) has long recognized the benefits of computer-aided design (CAD) systems, and has encouraged its design architect/engineers (A/Es) to use this technology. However, traditional methods of training A/Es to use CAD have had only limited success, so USACE has investigated and developed various innovative, nontraditional methods. One such method, on-line embedded instruction, uses CAD software as the delivery medium for an on-line tutorial program.

This report discusses an on-line tutorial program developed for the Corps' standard CAD system, Intergraph MicroStation. An innovative feature of the Corps' tutorial program is its adaptive on-line help function, which includes both procedural and conceptual help material, presented to the user on the basis of his or her degree of CAD experience. The effectiveness of this tutorial was investigated in a USACE Technology Transfer Test Bed (T³B) demonstration, with particular attention on the adaptive on-line help function.

Findings indicate that the adaptive help function was effective for most test participants, but it could probably be modified to better address the needs of certain categories of learners.

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TECHNOLOGY TRANSFER TEST BED PROGRAM

FINDINGS AND RECOMMENDATIONS OF TEST/DEMONSTRATION

WORK UNIT NO./TITLE OF TEST: TTTB-SA-KNO

Test of MicroStation Computer-Based Instruction

PERFORMING LABORATORY: USACERL **PRODUCT/SYSTEM:** MicroStation Teaching Assistant

PERFORMING TEST SITES: USACE Engineering Activity/Capitol Area, Little Rock District, and Portland District

DESCRIPTION/OBJECTIVE OF TEST/DEMONSTRATION:

USACE design professionals and technicians from the three test sites completed five CAD lessons on a walk-in basis using the embedded instruction program with adaptive on-line help. Subjects were observed for their use of the help function during the lessons and were surveyed for their opinions about the effectiveness of the method. The objective was to investigate the effectiveness of on-line help in teaching a conceptual understanding of CAD systems.

RESULTS OF THE TEST/DEMONSTRATION:

It was concluded that the embedded instruction program was generally effective, but there were differences in the success of certain subgroups based on their degree of experience and whether or not they used help. Novice help users and experienced subjects who did not use help tended to feel more successful and positive about the tutorial than did the experienced help users and novice subjects who did not use help. The architect subgroup's survey responses shared a number of characteristics with the experienced help and novice nonhelp groups. Based on survey responses it was concluded that the adaptive on-line help function was effective. However, an unexpected finding was that about half of the participants in the test simply did not use the help function. It was hypothesized that the nonhelp users carried with them to the test a general aversion to help systems that was not addressed in the survey because it was not anticipated.

RECOMMENDATIONS FOR PRODUCT/SYSTEM:

It is recommended that adaptive on-line help should continue to be a feature of USACE computer-based instructional systems. In future revisions of MicroStation Teaching Assistant developers should consider "repackaging" the help interface so it less resembles a conventional help function, to which many potential users may have an aversion. As part of that effort the help screens and buttons should be relabeled to describe more accurately the kind of information available to the user. Also, the adaptive mechanism of the help system should be studied further and developed to better meet the learning needs and styles of users who fit the profile of the "experienced help user" and the "novice nonhelp user."

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave Blank)		2. REPORT DATE October 1991		3. REPORT TYPE AND DATES COVERED Final
4. TITLE AND SUBTITLE Adaptive On-Line Help for Embedded Instructional Systems			5. FUNDING NUMBERS WU TTTB-SA-KNO	
6. AUTHOR(S) Doris Smith Shaw, L. Michael Golish, Julie L. Webster, and Der-Shung Yang				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Construction Engineering Research Laboratory (USACERL) PO Box 9005 Champaign, IL 61826-9005			8. PERFORMING ORGANIZATION REPORT NUMBER TR P-91/52	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) HQUSACE ATTN: CEMP-ES 20 Massachusetts Avenue, NW WASH DC 20314-1000			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES Copies are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The US. Army Corps of Engineers (USACE) has long recognized the benefits of computer-aided design (CAD) systems, and has encouraged its design architect/engineers (A/Es) to use this technology. However, traditional methods of training A/Es to use CAD have had only limited success, so USACE has investigated and developed various innovative, nontraditional methods. One such method, on-line embedded instruction, uses CAD software as the delivery medium for an on-line tutorial program. This report discusses an on-line tutorial program developed for the Corps' standard CAD system, Intergraph MicroStation. An innovative feature of the Corps' tutorial program is its adaptive on-line help function, which includes both procedural and conceptual help material, presented to the user on the basis of his or her degree of CAD experience. The effectiveness of this tutorial was investigated in a USACE Technology Transfer Test Bed (T ² B) demonstration, with particular attention on the adaptive on-line help function. Findings indicate that the adaptive help function was effective for most test participants, but it could probably be modified to better address the needs of certain categories of learners.				
14. SUBJECT TERMS computer aided design computer aided instruction			15. NUMBER OF PAGES 42	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT SAR	

FOREWORD

This project was demonstrated as part of the Technology Transfer Test Bed (T³B) program under the T³B Work Unit entitled "Computer-Aided Design Instruction (MicroStation)." The T³B demonstration was coordinated with the Corps of Engineers National Automation Team (CENAT). The research and development phase was conducted for the Directorate of Military Programs, Headquarters, U. S. Army Corps of Engineers (HQUSACE), under Project, "Test of MicroStation Computer-Based Instruction;" Work Unit TTTB-SA-KNO. The HQUSACE technical monitor was Hugh Adams, CEMP-ES.

The work was performed by the Facility Systems Division (FS) of the U.S. Army Construction Engineering Research Laboratory (USACERL). Dr. Michael J. O'Connor is Chief of USACERL-FS. The USACERL technical editor was Gordon L. Cohen, Information Management Office.

COL Everett R. Thomas is Commander and Director of USACERL, and Dr. L.R. Shaffer is Technical Director.

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ADAPTIVE ON-LINE HELP FOR EMBEDDED INSTRUCTIONAL SYSTEMS

1 INTRODUCTION

Background

The U.S. Army Corps of Engineers (USACE) has long used computer-aided design (CAD) for precision technical drawings. As the advantages of using CAD for concept design have become more apparent, USACE has encouraged its design architect/engineers (A/Es) to use it. In the past, traditional methods of training A/Es to use CAD have had limited success, so USACE has investigated and developed various innovative, nontraditional methods. The results of this research indicate that innovative training methods could be made more effective and complete by including conceptual instruction—concepts pertaining to all CAD systems regardless of developer or publisher.

The computer-based (or on-line) tutorial is one nontraditional approach to CAD education investigated for USACE by the U.S. Army Construction Engineering Research Laboratory (USACERL). A computer-based tutorial involves learning a skill before using it in a job task. This type of training is usually sequential and often "intelligent," meaning that the tutorial program actually responds to the student by monitoring him or her, providing feedback for expected errors, and offering instructional options as needed or desired. One variety of on-line tutorial is "embedded" instruction, which has proven to be a promising alternative to traditional methods of computer-based training. This technology involves integrating a tutorial program directly into the software environment being learned, using the system itself as a delivery medium for the lessons. Users can learn at their own pace on the same software they use in daily work. With embedded instruction, the problems encountered in learning—and the learning environment itself—are the same as those encountered in actual use.

In earlier research, USACERL developed a prototype for embedded instruction in AutoCAD, a widely used commercial CAD program.¹ Preliminary tests of this prototype showed that embedded instruction could successfully present basic techniques and offer a useful approach to problem solving. It was found that a professional audience could be given control over many tutorial options with confidence that they would use that freedom wisely. An important finding from related research was that users who learned several CAD systems understood general CAD concepts better than those learning their first system.² It was concluded from that research that better understanding of CAD concepts may lead to greater CAD productivity.

In addition to the embedded instruction for AutoCAD mentioned above, USACERL developed a similar tutorial for users of Intergraph MicroStation, the Corps' standard CAD software. This tutorial, called MicroStation Teaching Assistant, was based on the previous USACERL research, but included various improvements. For example, programmers eliminated the reminder prompt that told the user he or she had missed an opportunity to try a new command. It had been found that users sometimes deliberately bypassed such opportunities; many preferred to experiment freely rather than follow exact

¹ D.S. Shaw, L.M. Golish, and R.L. Johnson, *Intelligent Embedded Instruction for Computer-Aided Design (CAD) Systems*, Technical Report (TR) P-89/03/ADA201811 (U.S. Army Construction Engineering Research Laboratory, October 1988).

² D.S. Shaw and L.M. Golish, *Followup Studies of Embedded Instruction for CAD Systems*, TR P-90/10/ADA222509 (U.S. Army Construction Engineering Research Laboratory, May 1990).

procedures prescribed by the tutorial. Also, the error-checking feature was dropped as an automatic function and provided instead as an option available at the user's demand. The most significant change, however, was the addition of adaptive, user-sensitive help incorporating information on general CAD concepts. When experienced CAD users invoked the help function, they were first directed to help screens dealing with pertinent conceptual issues. On the other hand, novices were taken first to help screens telling them how to carry out a specific procedure. Both groups were free to view the other screen if they desired. Additionally, the system was capable of changing which kind of help screen was offered first, based on the individual's pattern of help usage.

To learn whether a conceptual help function can improve a user's understanding of general CAD concepts, a field test was funded under the Technology Transfer Test Bed (T³B) program. T³B is a USACE program of site demonstrations to ensure that research and development efforts are responsive to customer needs.

Objective

The objective of this research was to investigate the effectiveness of on-line help in teaching a conceptual understanding of CAD systems.

Approach

A general aim of this research has been to allow students great freedom to explore and experiment in the context of an effective embedded instruction program. While there are specific educational objectives for the training program, it was determined that the current study would produce the most meaningful results if the researchers studied adult students who set their own goals. Test subjects were studied to determine which elements of the embedded instruction produced significant learning gains. Although the researchers are ultimately interested in the overall effectiveness of this kind of training, they paid particular attention in this study to the effectiveness of this tutorial's most important innovation—on-line conceptual help.

The lessons in this embedded instruction covered the subject material commonly taught in introductory CAD courses. Since the target constituency for the end product is USACE design professionals and technicians, the lessons were field tested at three USACE sites: Engineering Activity/Capitol Area, Little Rock District, and Portland District. The tests used a walk-in training format. A test coordinator at each location administered the lessons by keeping records and helping the subjects get started. Subjects recorded demographic information about themselves, including age, gender, educational experience, computer experience, and CAD experience. Each subject's use of conceptual on-line help was studied during the training sessions. Finally, test subjects were surveyed for their opinions about the effectiveness of the training method.

The findings of this study were evaluated in the context of four questions:

1. Is the embedded instructional program effective?
2. Did the use of the help function differ among identifiable subgroups of test subjects?
3. Did the conceptual help screens teach general CAD concepts effectively?
4. Is the adaptive feature of the on-line help function effective?

Mode of Technology Transfer

In accordance with the Federal Technology Transfer Act of 1986 and Public Law 99-502, the program described in this report has been transferred through a Cooperative Research and Development Agreement (CRDA) between USACERL and Electronic Courseware Systems (ECS), Inc., of Champaign, IL. ECS refined and commercialized the USACERL prototype for teaching MicroStation, and it is now available under the trademark *Teaching Assistant for MicroStation*. The same concepts developed in this research could be adapted for a wide range of applications by USACE and private industry.

2 RESEARCH DESIGN

The Instructional Program

Effective computerized instruction is based on a knowledge of three factors: the subject area itself, the educational medium, and the stages in the learner's development of expertise. Since computer-based instruction attempts to reduce the need for human intervention in training, thorough analysis of the learning process is necessary. The teacher's usual accommodation of student needs must be predicted and simulated as closely as possible.

The subject area of this study involved not only procedural knowledge of a computer program but a conceptual understanding of how a computer program is used in the design process. For designers to make the computer a part of their design process, an expert level of understanding of CAD was needed. Design has traditionally been thought of as a product of the imagination and not subject to computerization, so some negative reactions to this approach were expected.

From initial observations, the following guidelines were adopted in planning the instruction:

1. The course content would be represented better by a concept specification hierarchy³ than by a traditional task analysis of skills. Different designers employed different procedural approaches.
2. A/Es would be encouraged to find ways to make the computer an extension of their own design processes. There was little acceptance of the idea of changing design practices to comply with constraints set by the computer.
3. The designer would be allowed time and space for individualized experimentation. Previous research showed wide variations in such needs.
4. In the interest of efficiency, some structure would be followed in the presentation. The lessons progressed from developing general familiarity with commands to design application concepts and, finally, more detailed procedures of editing and documentation.

The five lessons were designed, making use of CAD graphics to create the screen displays. CONTINU, BACK, and INDEX options appeared on the screen menu and were always active. A blank screen was always available for practice.

Previous research indicated that users wanted more feedback from the program, and more control over it. In response to these requests, the MicroStation version offered an optional exercise, CHECK, to monitor the drawing file and offer very specific information to the user. This program featured an "expert critic" that diagnosed user additions to the drawing database. If students satisfied the requirements of the task stated in the exercise, the user received an "OK" as feedback. If the requirements were not met, the expert critic attempted to determine why the problem occurred, and offered corrective feedback if possible. For unpredicted errors, the exercise should have been repeated and the user encouraged to try again. Also, there was a reminder to try the exercise if no changes had been made in the drawing file. The expert

³ M. Birenbaum and D. Shaw, "Task Specification Chart: A Key to a Better Understanding of Test Results," *Journal of Educational Measurement*, Vol 22 (1985), pp 219-230.

critic was available only if the user chose the CHECK function from the screen menu. If the student was merely browsing or reviewing, the computer system would not interrupt.

Extra help was offered from some lesson screens by typing "UC=X" or choosing XHELP from the screen menu. This help was context-sensitive; the same keyboard command produced different help screens from different lesson pages. At the beginning of the embedded MicroStation tutorial, the program asks: "Are you experienced in a CAD program other than Intergraph systems?" The response to this question dictated which of two help screens was offered first when the user sought extra help. Conceptual examples were offered as primary on-line help for experienced CAD users, while the more traditional procedural help was provided to new CAD users. For additional help, the subject could always obtain the other help screen. As the research progressed, adaptive on-line help was implemented to modify the user's help choices. If a test subject repeatedly demonstrated a preference for procedural help, regardless of his or her experience level, the program would learn to display that type of help screen to the user first. An example of the help screen sequence is shown in Figures 1, 2, and 3.

The system maintained several counters to keep track of how the subject used the on-line help screens. Whenever the subject came to a screen with the on-line help option, the system increased a counter, TP, by 2. For each actual use of an on-line help screen, the system incremented another counter, TA, by 1. The ratio TA:TP was updated whenever the user returned to the lesson screen from the help screen. If this ratio was greater than 0.8:1, the system recorded this information and reset the values of TP and TA to 0. If this ratio exceeded 0.8:1 three times, the system reset the subject's experience level. This was done because the system detected that the subject repeatedly was not satisfied with the first on-line help screen and asked for a second one.

Field Test

Three test sites agreed to solicit subjects to work through the lessons and complete the survey form reproduced in Appendix A. The sites funded under T³B were three USACE offices—Engineering Activity/Capitol Area, Little Rock District, and Portland District. Minimal written documentation was provided to accompany the lessons. Each site named a coordinator who was responsible for installing the program, helping the learners start, and being available for questions at appointed hours. The objective was to conduct the testing through the site coordinators rather than an outside project director. This arrangement was predicted to produce more realistic data even though it might also produce incomplete records and unexpected differences among the test sites. In addition, this configuration was the most economical way to use the programs and was expected to help reveal any weaknesses in the instruction.

All data were provided anonymously. The site coordinator knew only the numbers of test subjects, but did not know the survey results. Demographic information collected included age, gender, computer/CAD experience, and educational background. Because professionals who served as test subjects in related previous research showed a clear understanding of their own needs and state of knowledge, it was not considered necessary to give a final test. The user's level of understanding was determined on the basis of survey items 1, 10, and 27 in Appendix A.

Other sets of survey items provided information about learning style, enhancements or prerequisites, attitudes about computer use and computer-based instruction, and reactions to the on-line help. Responses

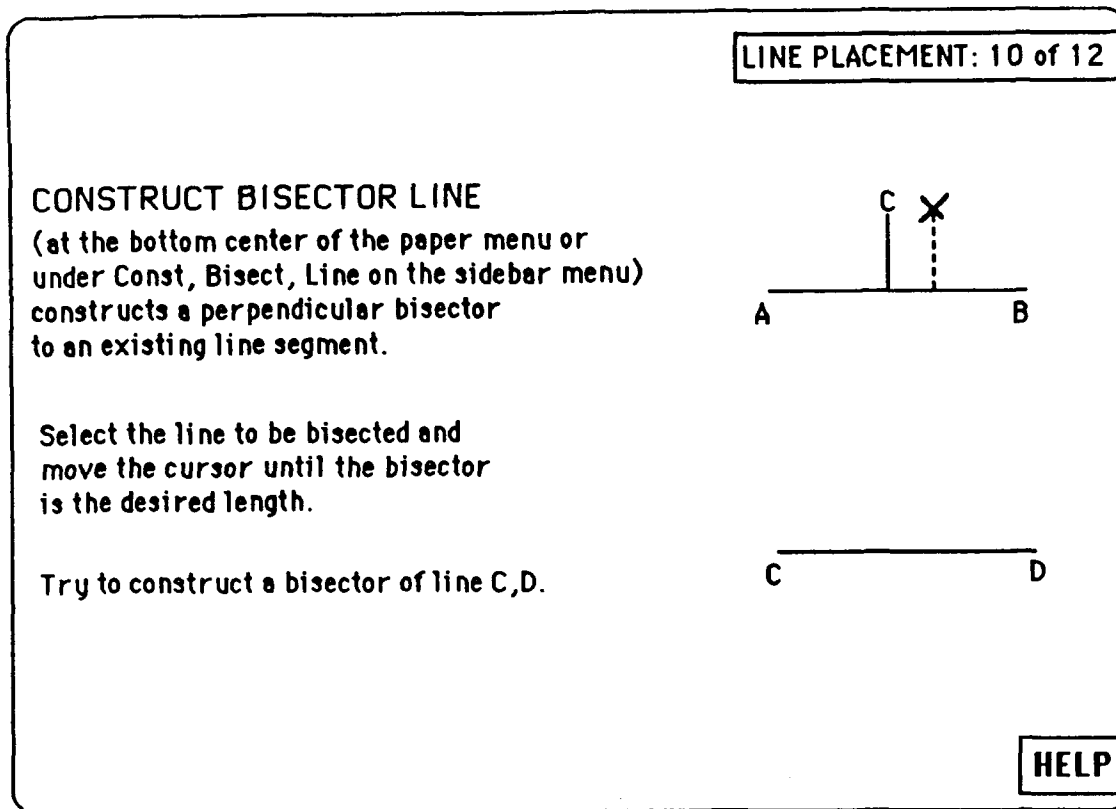


Figure 1. The Screen With On-line Help Available.

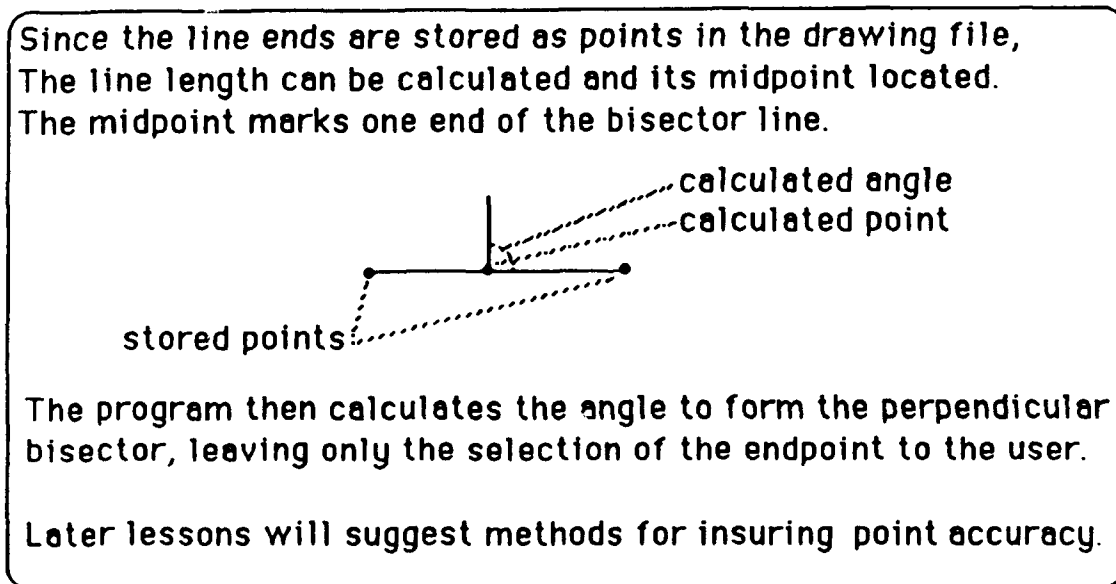
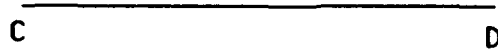


Figure 2. A Concept-based Help Screen for Users With CAD Experience.

- First select the CONSTRUCT BISECTOR LINE command.

You may use the digitizer on the tablet menu,
select Const from the main screen menu, Bisect,
Line from the second menu, or type the command.

- Place a data point on the line you wish to bisect.
- Place a data point for the end of the bisector.



The bisector will be drawn as you
move the cursor. The length of the
bisector will equal the distance
from the cursor to the original line.

Figure 3. A Procedure-oriented Help Screen for New CAD Users.

to the survey were subjected to the Student Problem Package (SPP) analysis⁴ to determine whether any category of test subjects answered significantly different from the others. The findings are summarized in Chapter 3. Sorted survey data are shown in Appendix B.

⁴ D. Harnisch and N. Romy, *SSP Student Problem Package on the IBM-PC* (University of Illinois, 1985).

3 FINDINGS

Sample Demographics

Fifty-four test subjects responded to the survey. Sixteen of the subjects were female, representing 30 percent of the group. The average age of the subjects was 34.8. The division by discipline was: 6 architects, 16 civil engineers, 8 mechanical engineers, 4 structural engineers, 11 technicians, and 9 from miscellaneous groups. They represented USACE test sites. On a scale of 1 (no computer experience) to 3 (more than 1 year of computer experience), the average was 2.68. Twenty-four of the subjects reported experience with AutoCAD, a widely used CAD system different from the one being taught. Four had a high level of expertise in other CAD systems and 26 had little or no experience with CAD systems other than MicroStation, the system used in this investigation.

SPP Analysis

The SPP analysis (noted in Chapter 2) required that each item be scored on a bipolar scale (agree/disagree). Four options (strongly agree, agree, disagree, strongly disagree) were offered to the subjects because subjects in related previous research found it difficult to make a choice when given only two. Experience demonstrates that the tendency to respond to "strongly agree" or "strongly disagree" depends on the disposition of the individual and cannot necessarily be considered an absolute indicator of how strongly the subject agrees or disagrees. Therefore, for the purpose of the SPP analysis, responses were entered as 1 (any level of agreement) or 0 (any level of disagreement).

The survey items were conceived to measure the user's attitudes toward computers, computer-based instruction in general, this particular computer-based program, the subject matter being taught (in this case the MicroStation software), and specific features of the system. The survey was conducted under the reasonable assumption that in an adult professional group (such as the ones participating in the study), attitude is an essential measure of a training program's success. An unfavorable attitude about the training program (or the system being taught) is likely to impede both the learning process and the likelihood of further study. The survey statements were originally framed as positive statements, but about half the statements on the user questionnaire were recast as negative. A subject's disagreement with a negative statement on the questionnaire (e.g., "I had trouble following the directions...") was taken to indicate agreement with the positive version (e.g., "I had no trouble following the directions...").

In Table 1 and Table 2, and also for the purpose of the analysis sort, negative questionnaire items were restored to their positive phrasing, and the subjects' responses to those items were adjusted accordingly to preserve the meaning of their answers. Organizing all the questionnaire items and responses in parallel phrasing makes interpretation of the data more straightforward to communicate.

The SPP sorts and arranges the data from the most "right" answers to the least (top to bottom), and from the highest level of agreement to the least (left to right). This makes it possible to examine the items in the order they are presented in Tables 1 and 2.

The student agreement scores—the percentage of the entire sample agreeing with the majority of the other participants—ranged from 90.6 percent to 56.3 percent, with a mean of 75.98 percent. The average raw score for the 32-item survey was 24.31, with a standard deviation of 2.93. Examination

Table 1**Items With 75 Percent or Greater Agreement**

Sorted Index	Original Index	Survey Items	Agree (%)	Disagree (%)
1	11	The first lesson was easy enough that I didn't feel frustrated.	98	2
2	13	Trying the MicroStation commands helped me learn.	98	2
3	32	I would like to see more advanced lessons made available.	98	2
4	2	I like MicroStation.	96	4
5	8	I believe that I could use MicroStation in my work.	96	4
6	12	I like working with computers.	96	4
7	17	The time I used for the lessons was well spent.	96	4
8	26	I expected to like doing the computerized lessons.	96	4
9	22	I liked being able to page back and use an index.	94	6
10	1	I feel generally competent with the MicroStation concepts covered in the computerized lessons.	93	7
11	28	I usually knew when I did things wrong in the lessons.	91	9
12	30	I like computer-based instruction.	91	9
13	23	The computer helps me consider different possibilities in my design.	89	11
14	24	When I asked for help I wanted to find procedures.	89	11
15	9	I had no trouble following the directions in the lessons.	87	13
16	15	The lessons were not too difficult for me.	85	15
17	5	The lessons helped me learn more quickly than I do from classrooms or textbooks.	80	20
18	16	The help screens were very helpful.	80	20
19	19	A teacher does not need to be present during the computerized lessons.	80	20
20	27	I understand a lot about MicroStation.	78	22
21	31	The help screens helped me understand how MicroStation works.	78	22

Table 2

Items With Less Than 75 Percent Agreement

Sorted Index	Original Index	Survey Items	Agree (%)	Disagree (%)
22	29	I like walk-in training better than scheduled classes and labs.	70	30
23	14	Most of the lessons were not too long for a single session.	70	30
24	18	I didn't need more feedback from the computer.	65	35
25	21	By the end of the lessons, I usually only needed one help screen to answer my questions.	63	37
26	20	I usually didn't look at both help screens when they were offered.	50	50
		-----50%-----		
27	6	I looked at the help screens often.	44	56
28	10	I feel capable of teaching MicroStation to others.	44	56
29	7	I used the help screens more often at the beginning of the lesson sequence than I did at the end.	41	59
30	25	Having previous computer experiences is not necessary before using the embedded MicroStation instruction.	41	59
31	3	Having previous experiences in drawing and/or drafting is not necessary before attempting the MicroStation instruction.	33	67
32	4	The lesson documentation is not necessary.	17	83

For the different discipline groupings, the mean raw scores were as follows:

Architects	24.17
Civil Engineers	23.69
Mechanical Engineers	23.62
Structural Engineers	26.75
Technicians	24.37
Miscellaneous	25.0

of the different groupings reveals that females had a mean raw score of 24.35 and the males averaged 24.3. Novices averaged 24.5 and experienced CAD users averaged 24.14. The mean raw score for those under 35 years old was 24.24, and it was 24.4 for those over 35. None of these differences is statistically significant.

The agreement score for the structural engineers was statistically higher than the mean score for all groups. While they were all from the same test site and their scores may reflect a group dynamic effect, it is still interesting to note that they differed from the group average on four of the items pertaining to the help function. They agreed with items 25, 27, and 29, indicating that they only needed one help screen to answer their questions, looked at the help screens often, and used the help screens more at the beginning of the lesson sequence. On item 26 they indicated that they usually looked at both help screens. All of these differences were statistically significant to at least a 0.95 confidence level.

It is possible to look at any subject record after the data is sorted and determine whether the test subject has responded as expected by the researchers on any item. For example, if student A, whose score is 15 on a 20-item survey, lists the following answers:

1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0

he or she would be answering in the expected pattern. Based on the sort of the data used here (as mentioned above), the items to the left represent the ones the group most frequently agreed with, and the five at the right represent the ones most often answered "wrong" (in terms of the researchers' predictions) by the tested group. Another subject in the same survey, whose answer list looks like this:

1 1 1 0 1 1 1 1 0 1 1 1 1 0 1 0 0 1 1 1

would be considered unusual. The score is still 15, but this subject has "missed" several items most often agreed with in this group. This subject has also agreed with the three items at the right, which most of the group did not agree with. The SPP would calculate a high "caution index" for the second subject. Another name used for this type of calculation is "nonconformity index." The entire sorted set of data is shown in Appendix B. Lines have been drawn through the data to represent the expected dividing lines in both the student and the item records.

A number of items in this survey proved not to be truly bipolar upon analysis. The answer patterns on such items did not conform well to the overall group agreement/disagreement pattern for most items. The most obvious cases of this were items 1, 5, 8, 14, 25, 26, 27, 30, 31, and 32. Items 1 and 5 had such a high level of agreement, however, that nonconformity has little meaning. In the list of items cited above are four of the seven statements about the help screens—items 14, 25, 26, and 27 in the sorted list (Tables 1 and 2). For this reason, the items about help screens were analyzed further for other effects.

The "caution index" was also high for three of the architects in the sample. Since this represents 50 percent of the architects surveyed, that group also requires separate analysis. The other test subjects low in conformity with the rest of the group were four civil engineers, one technician, and three from the miscellaneous group, none of which represents a statistically significant number.

Item Analysis of the Architect Group

The architects displayed an unusual response pattern over the 32 test items, as shown in Figure 4. A comparison of the architects mean scores with those of the engineers and technicians reveals highly significant differences on some of the items. Some of these are shown in Tables 3, 4, 5, 6, and 7. The item numbers refer to the sorted item list.

Notice that the t-statistic for all items above is negative. This indicates that the architects disagreed with each statement. They also differed to a significance of 97.5 percent certainty with items 30 and 31, agreeing that previous computer or drawing/drafting experience was not necessary before using the embedded MicroStation instruction.

Item Analysis by Experience and Use of Help

The groups inexperienced in CAD differed significantly from the experienced CAD users on item 14, indicating that they wanted information on procedures when they asked for help. Experienced users differed significantly from the inexperienced on items 20 and 28, indicating that they understood a lot about MicroStation and that they felt capable of teaching MicroStation to others. Comparison of all item responses by experience is shown in Figure 5.

Figure 6 shows the items that help users and nonusers* differed on significantly: item 6 (nonhelp users liked working with computers better), item 8 (they expected to like the computerized lessons), item 10 (nonhelp users felt more competent with the MicroStation concepts in the lessons), and item 31 (nonhelp users agreed that previous computer experience was not necessary). The nonhelp users agreed that they didn't look at both help screens (item 26), but that is because they seldom looked at any. The help users agreed significantly that the help screens helped them understand MicroStation (item 21) and that by the end of the lessons they only needed one help screen to answer their questions (item 25).

Some interesting differences are found when looking at the experienced CAD users and the novices by whether they used help or not, and also when examining the responses of help users and nonusers by their level of experience. There were 12 subjects in each of two groups: novice users who used help and experienced users who used help. There were 14 subjects in the novice group that did not use help and 16 in the experienced group that did not use help. Figure 7 shows the group averages over the 32 survey items.

Experienced users who did not use help differed significantly from experienced users who used help in that they liked working with computers, felt confident with the concepts covered in the lessons, liked computer-based instruction, had no trouble following the directions in the lessons, and learned more quickly from the lessons than from classrooms or books (items 6, 10, 12, 15, and 17 in Table 1). Novices who used help differed from those who did not in that they gained an understanding of MicroStation through help, and liked walk-in training better than scheduled classes and labs (items 15, 21, and 22 in Tables 1 and 2). Novices who did not use help agreed with the statements that previous experience in drawing and drafting were not necessary for using the embedded instruction (item 31) and that a teacher did not need to be present in the classroom (item 19) significantly more often than novices who used help.

* For purposes of brevity, test subjects who did not use the help function are subsequently referred to as "nonhelp users."

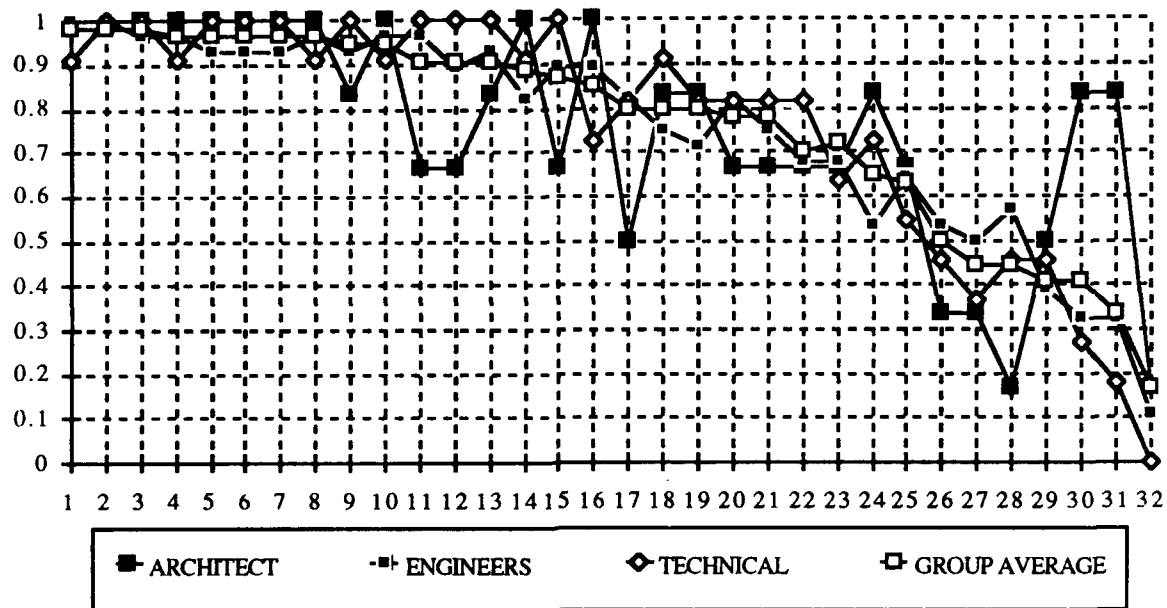


Figure 4. Architect Responses on Test Items.

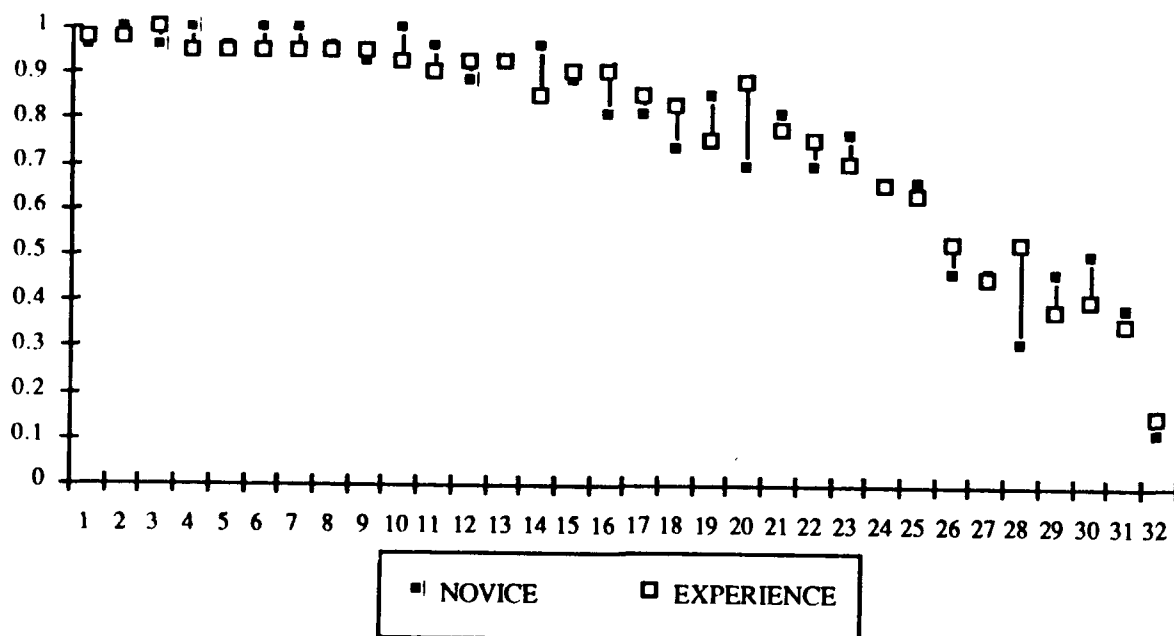


Figure 5. Item Responses by Experience.

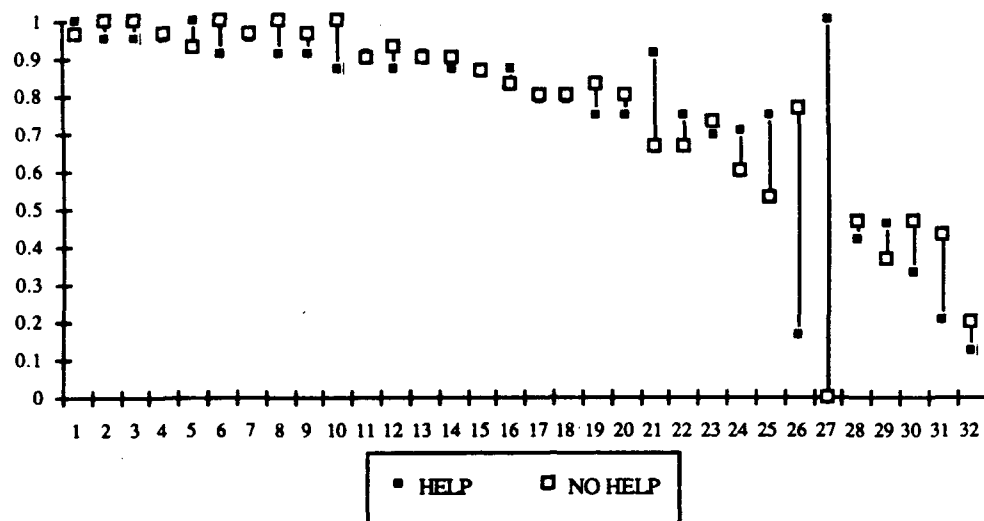


Figure 6. Item Responses by Help Use.

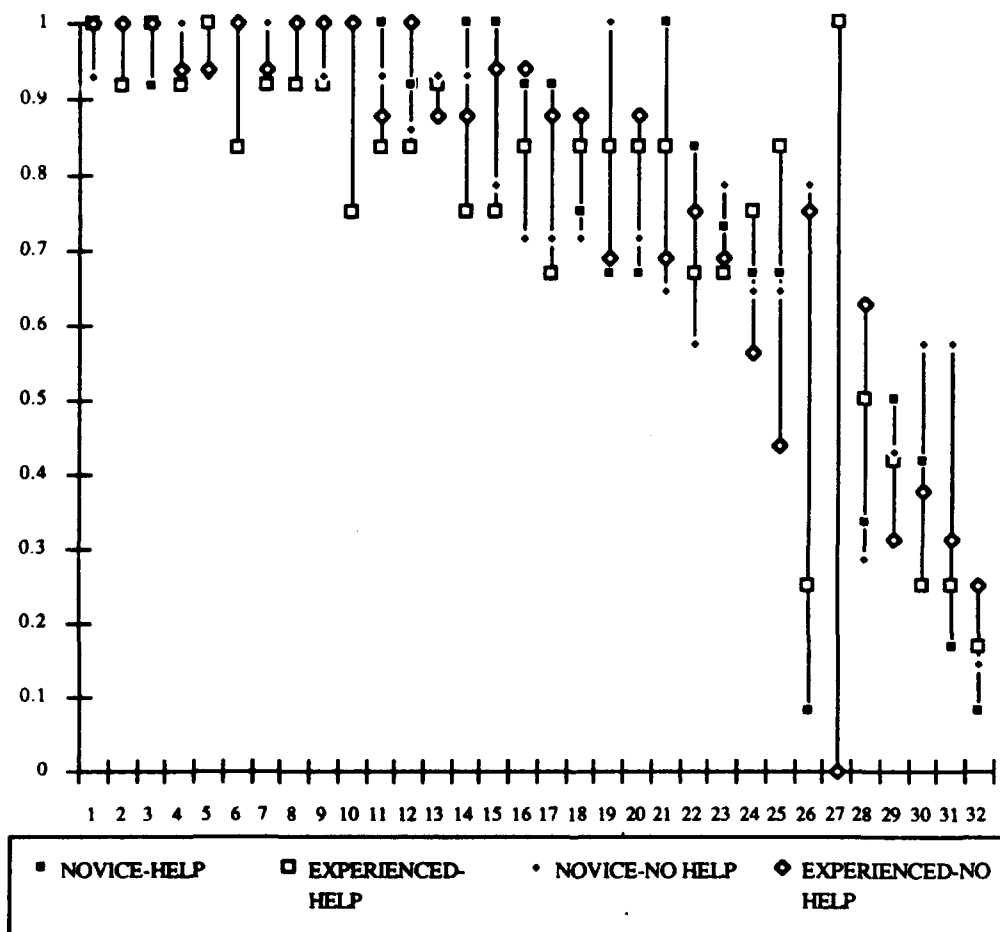


Figure 7. Item Responses by Experience and the Use of Help.

Table 3**Analysis of Item 11: "I usually knew when I did things wrong..."**

Variable:	Architects	Engineers and Technicians
Mean:	0.67	0.97
Std. Deviation:	0.52	0.16
Observations:	6	39
t-statistic:	-3.03	Hypothesis:
Degrees of Freedom:	43	Ho: $\mu_1 = \mu_2$
Significance:	0.004	Ha: $\mu_1 \neq \mu_2$

Table 4**Analysis of Item 12: "I like computer-based instruction."**

Variable:	Architects	Engineers and Technicians
Mean:	0.67	0.92
Std. Deviation	0.52	0.27
Observations	6	39
t-statistic:	-1.89	Hypothesis:
Degrees of Freedom:	43	Ho: $\mu_1 = \mu_2$
Significance:	0.065	Ha: $\mu_1 \neq \mu_2$

Table 5**Analysis of Item 15: "I had no trouble following the directions..."**

Variable:	Architects	Engineers and Technicians
Mean:	0.67	0.92
Std. Deviation:	0.52	0.27
Observations:	6	39
t-statistic:	-1.89	Hypothesis:
Degrees of Freedom:	43	Ho: $\mu_1 = \mu_2$
Significance:	0.065	Ha: $\mu_1 \neq \mu_2$

Table 6**Analysis of Item 17: "The lessons helped me learn more quickly..."**

Variable:	Architects	Engineers and Technicians
Mean:	0.50	0.82
Std. Deviation:	0.55	0.39
Observations:	6	39
t-statistic:	-1.78	Hypothesis:
Degrees of Freedom:	43	Ho: $\mu_1 = \mu_2$
Significance:	0.082	Ha: $\mu_1 \neq \mu_2$

Table 7**Analysis of Item 28: "I feel capable of teaching MicroStation to others."**

Variable:	Architects	Engineers and Technicians
Mean:	0.17	0.54
Std. Deviation:	0.41	0.51
Observations:	6	39
t-statistic	-1.71	Hypothesis:
Degrees of Freedom:	43	Ho: $\mu_1 = \mu_2$
Significance:	0.094	Ha: $\mu_1 \neq \mu_2$

Nonhelp users who were experienced agreed with the following statements significantly more frequently than nonhelp users who were novices: item 12 (I like computer-based instruction), item 16 (The lessons were not too difficult for me), and item 28 (I feel capable of teaching MicroStation to others). Novice nonhelp users also differed from experienced nonhelp users on whether a teacher need be present during lessons (item 19) and whether previous drawing and drafting experience was unnecessary (item 31).

Help users who were novices agreed with items 6, 10, 11, 14, 15, 17, and 21 significantly more than help users who were experienced in CAD. Novice help users liked working with computers, felt generally competent with the MicroStation commands in the lesson, usually knew when they did things wrong in the lessons, asked for help when they wanted to find procedures, had no trouble following the directions in the lessons, believed they learned more quickly from the lessons than from classes or books, and indicated that the help screens helped them understand how MicroStation works.

Comparing the experienced group that used help with the novices who did not use help, the experienced group exhibited significant agreement with items 6, 10, 19, 30, and 31. This was interpreted to mean that they agreed that they liked working with computers, felt generally competent with the

MicroStation commands in the lessons, felt that a teacher does not need to be present, and did not believe that previous experience with computers or drawing and drafting were necessary.

The experienced group that did not use help agreed with statements 20 and 28 (indicating they understood a lot about MicroStation and felt capable of teaching it) significantly more than the novice group that did use help. The novice group that used help agreed significantly more than the experienced group that did not use help that the help screens aided them in understanding how MicroStation works (item 21).

4 INTERPRETATION OF THE FINDINGS

The following discussion interprets the findings of the study in the context of the four research questions identified in Chapter 1:

1. Is the embedded instructional program effective?
2. Did the use of the help function differ among identifiable subgroups of test subjects?
3. Did the conceptual help screens teach general CAD concepts effectively?
4. Is the adaptive feature of the on-line help function effective?

Effectiveness of the Instructional System

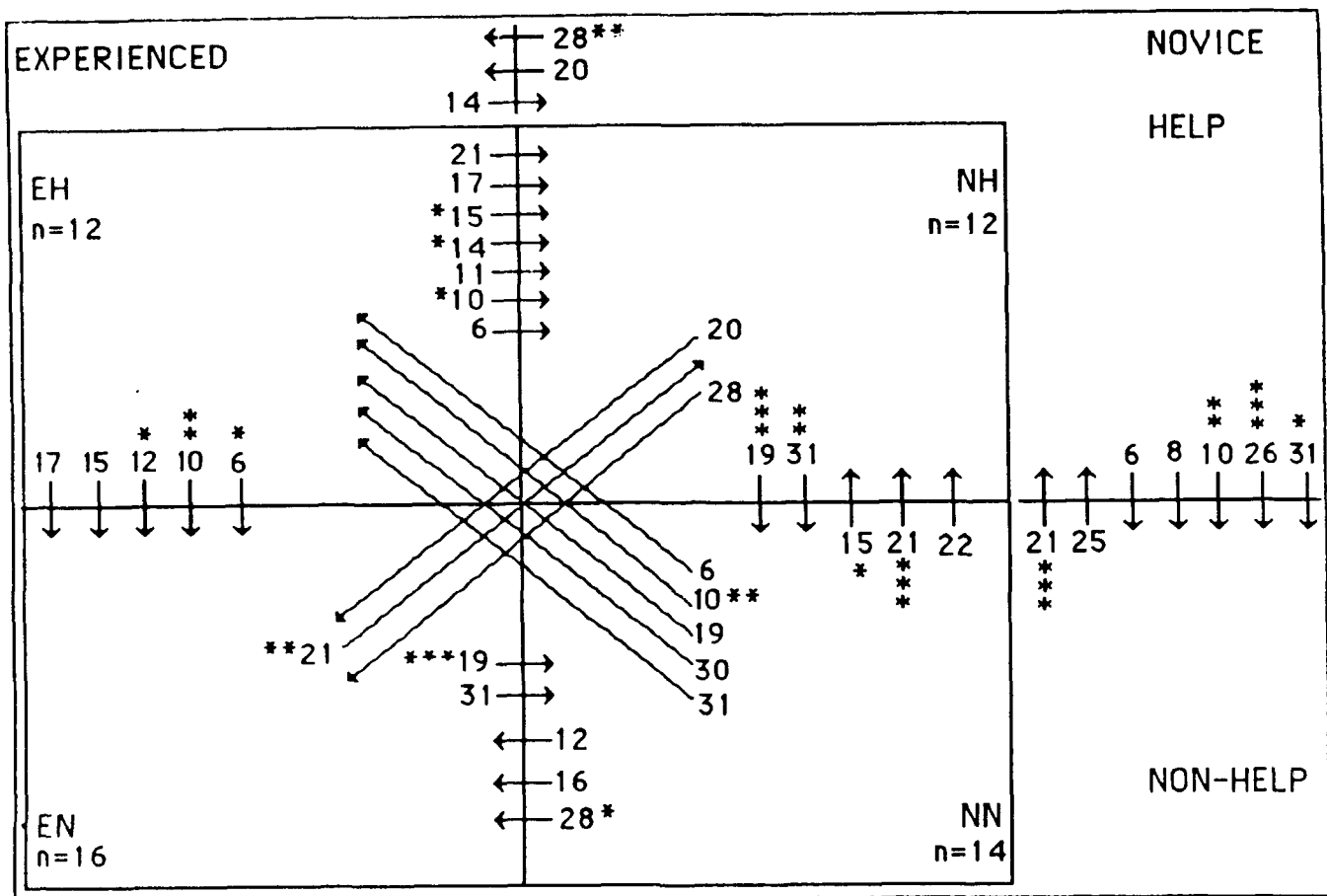
Based on the findings of the test group survey, the researchers consider the instructional program to have generally been successful. On 26 of the 32 items, the test subjects agreed with the desired or predicted statement more than 50 percent of the time. On 21 items there was more than 75 percent agreement and on 12 items there was over 90 percent agreement (Tables 1 and 2). On the six items receiving less than 50 percent agreement, four were not bipolar, indicating that some factor not related to the success of the instruction was a factor. One of the two remaining survey statements, item 28 ("I feel capable of teaching MicroStation to others"), was clearly an unattainable goal for the majority considering that the instruction had been very short and basic. Item 29 ("I used help screens more often at the beginning of the lesson...") applied only to help users and did not imply anything conclusive about the overall success of the embedded instructional program.

Subgroups Identified by Experience and Help Use

Figure 8 charts the agreement patterns of four subgroups. The top two quadrants represent help users and the bottom two represent nonhelp users. The two left quadrants represent experienced subjects and the two right ones represent novices. Note that some data are represented in the top and right margins of the figure; these items are sorted only on the basis of experience (items 14, 20, and 28 at top) or help usage (items 6, 8, 10, 21, 25, 26, and 31), but not both criteria. The numbers by the arrows represent items on the sorted lists (Tables 1 and 2) and the arrowheads point in the direction of the group that agreed more with each item.

Experienced users in general agreed more than novices with item 20 ("I understand a lot about MicroStation") and item 28 ("I feel capable of teaching MicroStation to others"). Novices agreed more than the experienced with item 14 ("When I asked for help I wanted to find procedures").

Nonhelp users generally agreed more than help users with item 6 ("I like working with computers..."), item 8 ("I expected to like doing the computerized lessons"), item 10 ("I feel generally competent with the MicroStation concepts covered in the computerized lessons"), item 26 ("I usually didn't look at both help screens when they were offered"), and item 31 ("Having previous experiences in drawing and/or drafting is not necessary before attempting the MicroStation instruction"). Help users agreed more than nonhelp users with item 21 ("The help screens helped me understand how MicroStation works") and item 25 ("By the end of the lessons, I usually only needed one help screen to answer my



EH = experienced help users
 NH = novice help users
 EN = experienced nonhelp users
 NN = novice nonhelp users
 *** = 0.99 confidence interval
 ** = 0.975 confidence interval
 * = 0.95 confidence interval
 no asterisk = 0.90 confidence interval

Figure 8. Survey Agreement Patterns Sorted by Experience and Use of Help.

questions"). The nonhelp group would be expected to disagree with these items since those test subjects did not use help.

The Experienced Help Group

In Figure 8 it is clear that the experienced help (EH) users disagreed on two items with other groups: item 6 ("I like working with computers") and item 10 ("I feel generally competent with the

MicroStation concepts covered in the computerized lessons"). On item 15 ("I had no trouble following the directions in the lessons") and item 17 ("The lessons helped me learn more quickly than I do from classrooms or textbooks"), EH users disagreed with both the experienced nonhelp (EN) users and the novice help (NH) group. Help users in general disagreed with nonhelp users on items 6 and 10. This suggests that help users—particularly experienced ones—are less comfortable with computers and with their ability to learn from computer-based instruction than the test subjects who did not use help. Two of the four test subjects who agreed that they didn't like computer-based instruction (item 12) came from the EH group. The EH group disagreed with novice nonhelp (NN) users that a teacher need not be present (item 19), and with help users in general that previous experiences in drawing and drafting were necessary (item 31) before using the instruction. EH users also felt that computer experience was a prerequisite for the instruction (item 30). Surprisingly, EH users disagreed with NH users on item 11 ("I usually knew when I did things wrong in the lessons"). They also disagreed with NH users on two items concerning help; item 14 ("When I asked for help I wanted to find procedures") and item 21 ("The help screens helped me understand how MicroStation works").

The way the adaptive program worked, test subjects who said they were experienced with CAD were directed to the conceptual help screen first. Those who frequently viewed the second screen would eventually be presented with the procedural screen first. If they continued to consult both help screens, the default would then switch back to conceptual help. For those who did not want procedural help it may have been disturbing when the procedural screen appeared first. Most of the users who did not want procedural help were in the EH group. Considering that the EH group did not agree that they understood a lot about MicroStation (item 20), many of them may have been seeking conceptual help despite the fact that they had CAD experience. This point is important to remember in the discussion of teaching concepts that follow this section.

The Novice Help Group

The other group that would have been likely to experience the switching of help screen priority was the NH group. They reported that they wanted to find procedural help, which they did at the beginning, but seemed to profit from whatever help was offered. The NH group differed from the NN group in desiring a teacher to be present (item 19) and in feeling that previous experience in drawing and drafting was prerequisite to the instruction (item 31). The NH group agreed more than the NN group with item 15 (they had no trouble following the directions), item 21 (they felt that the help screens helped them understand), and item 22 (they liked walk-in training better than classes and textbooks). The NH group appears to favor computer-based training with a teacher present over a traditional classroom environment. This group seemed quite successful with the instructional program. Their responses were statistically very strong, particularly for items 15 and 21, which emphasizes their suitability for embedded instruction with adaptive on-line help.

The Novice Nonhelp Group

The NN users were apparently somewhat uncomfortable with the lessons. Compared with the NH and EN groups, they did not desire a teacher (item 19) and did not consider previous experience with drawing and drafting helpful (item 31). They had some trouble following the directions (item 15) and preferred scheduled classes and labs over walk-in training (item 22). The NN group agreed more than the EN group with item 16 ("The lessons were not too difficult for me"). They did not like computer-based instruction (item 12) and did not feel capable of teaching MicroStation (item 28). However, they disagreed more than the EH users with item 6 (like to work with computers), item 10 (generally feel

competent with the concepts covered in the lessons), and item 30 (do not consider computer experience necessary to use the lessons). The learning style of the NN group may be better suited to a computer-based instructional method other than this tutorial.

The Experienced Nonhelp Group

The EN group seems to have been ideally suited to this kind of embedded instruction. To recap their responses in comparison with the other groups, it can be stated that EN subjects learned quickly from the tutorial, had no trouble following the directions, did not find lessons too difficult, liked computer-based instruction, liked working with computers, felt competent with the MicroStation lessons, understood a lot about MicroStation, and felt capable of teaching MicroStation to others. They did not think a teacher needed to be present, that previous drawing and drafting experience was necessary, or that the help screens were useful. Especially on the basis of their responses to items 10, 20, and 28, one can clearly see that the help screens were not needed by this group. EN subjects were even able to solve procedural problems on the basis of the conceptual understanding they already possessed.

Interpretation of Subgroup Differences

According to the survey responses, the novices who used help and the experts who did not use help were the two most successful groups in terms of what they learned from the embedded instructional program. The NH users were in 78 percent agreement with all survey items while the EN group—the largest in the test sample—agreed 76 percent of the time. (The average for all groups was also 76 percent.) The NN group agreed with an average of 75.4 percent of the survey items, and the EH group agreed with about 74.5 percent of the items. Even in the EH group there was 69 percent agreement with the set of items mentioned above that differed statistically in disagreement with the other groups.

Based on these figures it appears that the tutorial instruction was quite effective for all groups. Nevertheless, future revisions of the tutorial should attempt to make the instruction more effective for the NH and EH user groups.

The Architect Subgroup

The architects in the test sample exhibited some differences, as reported in Chapter 3. They disagreed significantly with the professional groups on the following items:

- "I usually knew when I did things wrong in the lessons" (item 11).
- "I like computer-based instruction" (item 12).
- "I had no trouble following the directions in the lessons" (item 15).
- "The lessons helped me learn more quickly than I do from classrooms or textbooks" (item 17).
- "Having previous computer experiences is not necessary before using the embedded MicroStation instruction" (item 30).
- "Having previous experiences in drawing and/or drafting is not necessary before attempting the MicroStation instruction" (item 31).

Based on these items, the architects appear to share many characteristics of the EH users. Furthermore, their disagreement with items 12 and 15 (from the above list) plus item 28 ("I feel capable of teaching MicroStation to others") was characteristic of the NN group. It is interesting that two architects came from the EH group and two came from the NN group—the other two being split between the NH and EN groups. The architects averaged 41.67 in age, which was significantly older than the subject average (confidence interval 0.90). The EH group averaged 38.17 years old, which was significantly older than the EN group average (32 years old) but not significantly older than the group as a whole (34.8 years old). The NH and NN groups did not differ significantly from that average. Age may partially explain a subject's success with computer-based instructional programs, but it cannot be considered the main factor.

It has been suggested that architects do not have a long history of using CAD for design purposes, which requires a strong conceptual understanding of computer capabilities. The use of a computer-based tutorial may not seem relevant to work that the designer considers inappropriate for computerization. CAD's ability to apply several solutions (e.g., aesthetic, energy-related, structural) to the same design problem in a relatively short time has gone unappreciated in the architectural community. The fact that many architects *do* use CAD systems to improve their designs is not common knowledge among architects. Promoting computer-based instruction for architects, therefore, presents the challenge of motivating architects to explore and use a technology that they perceive to be unrelated to the way they actually work.

5 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the findings of the user survey, the embedded tutorial instruction was effective for all groups. However, some of the subgroups analyzed appear to have learning styles or needs that should be addressed more fully in future revisions.

The novices who used help and the experienced subjects who did not use help—the NH and EN users respectively—were the two most successful groups in terms of what they learned from the embedded instructional program. Responses of the novice nonhelp (NN) and experienced help (EH) groups indicate that users in these categories may not be completely comfortable with computers and computer-based instruction in general, and this may interfere with their receptiveness to it. Also, architects as a subgroup appear to share some of the same discomfort with computers exhibited by the EH and NN groups.

Teaching CAD Concepts

Conclusions about the adaptive on-line help program studied here must include a note about how teaching concepts is different from teaching procedures. Procedural help is essentially step-by-step assistance in the execution of a command. A user is likely to know when he or she needs procedural help because the computer fails to behave in the expected or desired manner. This idea is supported by the survey results, which indicate that 89 percent of the test subjects wanted procedural help when they asked for help (Table 1, item 14). On the other hand it is much more difficult for users to identify their specific need when they do not understand a concept. Consequently it is difficult to deliver appropriate conceptual help based on user input or feedback.

In related research cited previously it was found that a conceptual understanding contributed to more effective use of CAD, but the major factor contributing to that understanding seemed to be previous experience with another CAD system. It seemed that such experience stimulated an awareness of global CAD concepts. The simple act of using more than one system prompted the user to think about differences and similarities in those systems. A key factor in this kind of learning process seems to be the stimulation of thought, which operates differently for different individuals. Some people may learn about concepts from help screens, but many others learn them from examples, pictures, and problems to solve. However, it is known that the learner must be prepared with underlying conceptual knowledge before new concepts can be absorbed.

The novices in this study who used help—the NH group—reported that the help screens were effective (Figure 8, item 21). Their main reason for invoking the help function was to learn procedures, which they were able to do with one or two keystrokes. Nevertheless, the conceptual screens that the NH group viewed may have built a foundation for the conceptual understanding of CAD, and they were not considered to be a problem. Experienced help users who were not looking primarily for procedural help may have obtained conceptual help screens which, considering the problems of delivering conceptual help noted above, may not have been appropriate for their individual style, level of expertise, or specific conceptual need. To make it possible for an adaptive help function to "know" a learner's needs, researchers must develop modes of user input and feedback that more accurately reflect the individual's needs.

Adaptive Help and Conceptual Understanding

The adaptive feature of this instructional system appears to account for the finding that a clear majority of the test subjects usually only needed one help screen to answer their questions by the end of the lessons (Table 1, item 25). The system adapted to their requirements if they made use of the help screens. While this benefit may not seem overly impressive in a case where only the order of two screens is involved, it actually can represent a major saving of time and can improve user satisfaction with the system.

Recommendations

On the basis of this research, it is recommended that an adaptive help function should continue to be a part of USACE computer-based instructional systems. While the findings show that many users can learn from a tutorial without consulting help, this function was considered valuable to a large subgroup of users who took part in the demonstration. In particular, help seems to make an important difference to novice learners—a key target group for any embedded instructional program.

Both procedural and conceptual help screens seem to be effective for a substantial portion of the users tested, but almost 50 percent of the test subjects chose not to use the help function—an unexpected result. Experience and anecdotal information suggest that in future research it may be appropriate to label this function as something other than "help." The term "help" has a negative connotation to some computer-experienced individuals. It is likely that much of their experience has been with help systems that were complicated, counterintuitive, or simply not helpful; many existing help systems do not even remain in view when the user attempts to follow their instructions. This may help explain why a large number of CAD-novice (but computer-experienced) users did not use the help in this study. Assuming that this is a reasonable hypothesis to test in future research, it is recommended that the help function be "repackaged" in more positive-sounding terms in subsequent versions of on-line tutorials. Relabeling the help screens as, perhaps, "picture" or "example" may help give the user a clearer idea of which screen he or she actually needs.

The initial help defaults of this tutorial should not be based on how experienced a user considers himself or herself to be. A user with confidence may perceive himself or herself to be experienced after a week-long CAD workshop, but another person with years of experience may indicate he or she is inexperienced if he or she has not used the system for a few months. For the instructional program tested here, the authors recommend that the initial help default is for the procedural screen since 89 percent of the subjects surveyed wanted procedural help (Table 1, item 14). Whenever possible, probability or other modeling techniques should be used to make the initial help settings rather than user answers to queries about level of experience.

Adaptive management of the instructional system should be studied further. One of the initial plans for this research was to keep a record of when the system adapted (changed the priority of the help screens) for each user, and note which help priority was set at the end of the tutorial. This was not possible with the version of MicroStation in which the tutorial was embedded at that time, but an updated version of the program will support this type of user tracking and recordkeeping. Such information will be an important link in the understanding of the user's intent.

While this system has proven to be generally effective, a deeper understanding of user needs and learning styles is necessary to make embedded instructional systems more flexible. Research beyond the scope of this study would include both a deeper coverage of concepts and access to a wider range of resources. As the information needed to be productive in automated systems increases, the capability to successfully adapt to the requirements of an individual user becomes more vital. The work with adaptive help capabilities has contributed to the success of this system, and it represents a logical point of departure for more advanced research in tailoring systems to users.

APPENDIX A: Survey Form

ID NUMBER _____

QUESTIONNAIRE

RESPOND TO THE FOLLOWING STATEMENTS BY
CHECKING THE APPROPRIATE COLUMN.

PLEASE DO NOT OMIT ANY ITEMS, PICK THE ONE THAT BEST APPLIES.

	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE
1. I feel generally competent with the MicroStation concepts covered in the computerized lessons.				
2. I like MicroStation.				
3. Having previous experiences in drawing and/or drafting is necessary before attempting the MicroStation instruction.				
4. The lesson documentation is necessary.				
5. The lessons helped me learn more quickly than I do from classrooms or textbooks.				
6. I didn't look at the help screens very much.				
7. I used the help screens more often at the beginning of the lesson sequence than I did at the end.				
8. I believe that I could use MicroStation in my work projects.				
9. I had trouble following the directions in the lessons.				
10. I feel capable of teaching MicroStation to others.				
11. The first lesson was easy enough that I didn't feel frustrated.				
12. I like working with computers.				
13. Trying the MicroStation commands helped me learn.				
14. Most of the lessons were too long for a single session.				
15. The lessons were too difficult for me.				

	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE
16. The help screens were not very helpful.				
17. The time I used for the lessons was well spent.				
18. I needed more feedback from the computer program.				
19. A teacher should be present during the computerized lessons.				
20. I looked at both help screens whenever they were offered.				
21. By the end of the lessons, I usually only needed one help screen to answer my questions.				
22. I liked being able to page back and use an index.				
23. The computer helps me consider different possibilities in my design.				
24. When I asked for help, I wanted to find procedures.				
25. Having previous computer experiences is necessary before using the embedded MicroStation instruction.				
26. I expected to like doing the computerized instruction.				
27. I don't understand very much about MicroStation.				
28. I usually knew when I did things wrong in the lessons.				
29. I like walk-in training better than scheduled classes and labs.				
30. I don't like computer-based instruction.				
31. The help screens helped me understand the way MicroStation works.				
32. I would like to see more advanced lessons made available.				

Sorted Student Problem Package Data

[illegible]

APPENDIX C: Raw Data From Survey

Discipline	Sex	Age	Computer Experience	CAD Experience	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
Subject 1 CIVIL ENGINEER	M	29	3	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 2 CIVIL ENGINEER	M	32	3	1	1	1	0	0	0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 3 TECHNICIAN	M	31	3	2	1	1	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 4 TECHNICIAN	F	46	3	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 5 CIVIL ENGINEER	M	48	3	2	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 6 TECHNICIAN	M	52	3	2	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 7	M	56	3	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 8 STRUCTUR ENGR	M	50	3	2	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 9 STRUCTUR ENGR	M	42	3	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 10 STRUCTUR ENGR	M	40	3	2	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 11 STRUCTUR ENGR	M	27	3	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 12 TRANSAFACMOT	F	41	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 13 CIVIL ENGINEER	M	37	3	2	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 14 ARCHITECT	M	58	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 15 CIVIL ENGINEER	M	24	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 16 CIVIL ENGINEER	M	35	3	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 17 MECH ENGINEER	M	19	3	2	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 18 MECH ENGINEER	M	23	3	2	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
Subject 19	F	20	3	2	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
Subject 20 LAND SURVEYOR	M	42	3	2	1	1	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 21 ARCHITECT	M	22	1	1	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 22	F	19	3	2	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 23 CIVIL ENGINEER	M	36	3	2	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 24 REALITY SPECIAL	M	50	3	2	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 25 TECHNICAL	F	30	3	2	1	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 26 TECHNICAL	F	48	3	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 27 CIVIL ENGINEER	F	26	3	2	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 28 MECH ENGINEER	F	26	3	1	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 29 CIVIL ENGINEER	F	23	3	1	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 30 CIVIL ENGINEER	F	28	3	1	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 31 MECH ENGINEER	M	39	3	1	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 32 CIVIL ENGINEER	F	25	3	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 33 LAND SURVEYER	M	34	3	2	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 34 ARCHITECT	F	29	2	2	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 35 MECH ENGINEER	M	28	2	2	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 36 ARCHITECT	M	44	3	1	0	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 37 GEOLOGIST	M	43	3	2	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 38 MECH ENGINEER	M	46	3	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 39 CIVIL ENGINEER	M	33	2	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 40 DRAFTSMAN	M	20	3	1	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 41 TECHNICIAN	M	24	3	2	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 42 CIVIL ENGINEER	M	28	2	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 43 TECHNICIAN	F	2	2	1	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 44 ARCHITECT	F	58	3	2	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 45 CIVIL ENGINEER	M	26	3	1	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 46 TECHNICIAN	F	52	1	2	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 47 ARCHITECT	M	39	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 48 MECH ENGINEER	M	32	3	2	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Subject 49 CIVIL ENGINEER	M	36	3	2	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 50 MECH ENGINEER	M	26	3	2	0	1	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Subject 51 TECHNICIAN	F	29	2	2	1	1	0	0	1	0	1	1	1</																								

ABBREVIATIONS

A/E	architect/engineer
CAD	computer-aided design
CADD	computer-aided drafting and design
CRDA	Cooperative Research and Development Agreement
EH	experienced help (users)
EN	experienced nonhelp (users)
NH	novice help (users)
NN	novice nonhelp (users)
SPP	Student Problem Package
T ³ B	Technology Transfer Test Bed
TR	technical report
USACE	U.S. Army Corps of Engineers
USACERL	U.S. Army Construction Engineering Research Laboratory

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